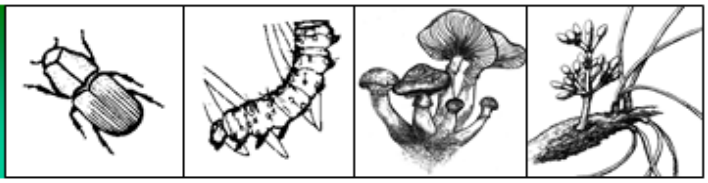
Forest Health Protection



20-03 *MARCH, 2020*

Story Map: Douglas-fir Tussock Moth 2019 Missoula Area Survey

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SUMMARY

In the summer of 2019 the Forest Health Protection-Missoula Field Office worked collaboratively with Montana Department of Natural Resources to conduct a field survey of Douglas-fir tussock moth populations in the Missoula area. The level of outbreak of this defoliator had not been noted in this area in past decades, making it an emerging pest of concern. The survey objective was to obtain some information on populations in and around recreation areas of Missoula, particularly Blue Mountain, Rattlesnake, and Pattee Canyon. Results of the survey suggest that in 2020 some areas will see a decline in activity, some will continue to experience defoliation, and some will see increased activity or appear as new outbreak spots.

This report is an accessible version of the content on the ESRI Story Map for the Douglas-fir Tussock Moth 2019 Area Survey. This document contains the text and photographs of the Story Map, however note that the content of the interactive maps cannot be fully reproduced here.

Citation for the AGOL Story Map:

Steed, B.; Chadwell, J.; Jenne, J.; Kaiden, J. 2020. Douglas-fir tussock moth 2019 survey. Missoula, MT: USDA Forest Service, Forest Health Protection. AGOL Story Map (available at: https://arcg.is/1jDOvy)

Citation for the Numbered Report:

Steed, B.; Chadwell, J.; Jenne, J.; Kaiden, J. 2020. Story Map: Douglas-fir tussock moth 2019 survey. FHP Numbered Report R01-20-03. Missoula, MT: USDA Forest Service, Forest Health Protection. 32 p.

United States Department of Agriculture	**Forest Service**	**Northern Region**	**Region One 26 Fort Missoula Rd Missoula, MT 59804-7203**	

TAB 1: IDENTIFICATION AND BIOLOGY

TAB 1 PHOTOGRAPH is of a mature Douglas-fir tussock moth larvae.
Photo by Jessica L. Jenne, USDA Forest Service, R1 Forest Health Protection.

Douglas-fir tussock moth (DFTM) (*Orgyia pseudotsugata*) is native to much of the western United States including Montana

Caterpillars feed primarily on Douglas-fir and true firs (subalpine and grand fir in Montana), and occasionally on pines, spruce, western larch, western hemlock and shrubs that are intermixed with preferred host trees. Because young larvae are wind dispersed or drop from above, they can be found on unusual hosts, especially in the understory.

For help with tree identification see Montana DNRC's Field Guide to Pinaceae.

PHOTO TITLE: Douglas-fir tussock moth caterpillar

Photo by Laura Lowrey, USDA Forest Service, R4 Forest Health Protection

The caterpillar is visible from egg hatch in June through pupation in July. During that time caterpillars go through 5-6 growth stages or instars, getting increasingly larger and eating more foliage with each molt. When young, the small caterpillars are blackish with very long white body hairs. When mature larvae (25-30 mm long) sport four tufts of white hair with golden tips, long black “pencil” tufts at both the front and back ends, and white hairs radiating from red spots along their sides.

PHOTO TITLE: Douglas-fir tussock moth cocoons

Photo by Jessica L. Jenne, USDA Forest Service, R1 Forest Health Protection.

Adult moths hatch from spindle shaped, webbed cocoons from late July to early September. The females are wingless, remaining on top of their cocoons where they emit pheromones to attract males, mate, and lay their eggs.

PHOTO TITLE: Douglas-fir tussock moth egg masses and two wingless females

Photo by Jessica L. Jenne, USDA Forest Service, R1 Forest Health Protection.

Winged males are tan to brown moths with white spot on their wings.

PHOTO TITLE: Douglas-fir tussock moth adult male

Photo by William M. Ciesla, Forest Health Management International, Bugwood.org

Cocoons are found mostly on branches or twigs, but become more common on tree trunks and objects on the ground when infestations become heavy.

PHOTO TITLE: Douglas-fir tussock moth cocoons and egg masses on the trunk of a heavily infested Douglas-fir

Photo by Jessica L. Jenne, USDA Forest Service, R1 Forest Health Protection.

The egg mass consists of 200 to 400 white spherical eggs attached to the female's cocoon in one to three layers and covered with a gelatinous substance intermixed with body hairs. Overwintering of the insect is done in this egg stage.

PHOTO TITLE: Healthy Douglas-fir tussock moth egg mass

Photo by Jacob S. Chadwell, USDA Forest Service, R1 Forest Health Protection

Compare this healthy egg mass to ones that are old or parasitized (TAB 6).

For more info see A Field Guide to Disease and Insect Pests of Northern and Central Rocky Mountain Conifers.

TAB 2: SIMILAR INSECTS

TAB 2 PHOTOGRAPH is of a rusty tussock moth larvae
Photo by Harvey Schmidt, Creighton, Saskatchewan, Canada; Blog - Harvey's Spiders and Stuff

Rusty Tussock Moth (RTM) looks much like DFTM

Rusty tussock moth (RTM) (*Orgyia antiqua*) is common at low numbers - often as a solitary feeder - on a wide range of shrubs and trees, particularly huckleberry. It looks very much like DFTM although the four tufts and overall body hairs are a solid off-white. It is not known to cause widespread, extreme defoliation in conifers has been of concern in huckleberries. This species is not native but originally from Europe.

PHOTO TITLE: Rusty tussock moth caterpillar

Photo by Brytten E. Steed, USDA Forest Service, R1 Forest Health Protection.

Cocoon and egg masses of RTM are relatively hairless compared to DFTM.

PHOTO TITLE: Douglas-fir tussock moth egg mass and wingless female

Photo by Gemma Warner (www.uksafari.com).

For more information see rusty tussock moth information sheet from Natural Resources Canada.

Western spruce budworm (WSBW) is also an active and important defoliator on Douglas-fir and true firs.

Western spruce budworm (WSBW) (*Choristoneura freemani*) is also an outbreak defoliating moth that often overlaps in feeding (hosts and range) with DFTM. Chronically active for several years in Montana the WSBW caterpillar webs together dead needle at the ends of Douglas-fir, spruce, true fir and understory larch. In this hiding area it feeds on newly emerging foliage. Annual damage is less than that of DFTM due to its preference for only the new needles. However, years of chronic feeding can result in denuded tree tops and thin crowns, with some trees in the understory becoming nearly fully defoliated.

Caterpillars of WSBW look very different from those of DFTM; they are green-brown, smooth (no hairs), with white spots on each body segment.

PHOTO TITLE: Western spruce budworm caterpillar

Photo from Natural Resources Canada.

PHOTO TITLE: Webbing and needles of feeding western spruce budworm

Photo by Brytten E. Steed, USDA Forest Service, R1 Forest Health Protection.

Pupal cases of WSBW may be found inside webbed needles but are not covered in a cocoon.

PHOTO TITLE: Western spruce budworm pupal case

Photo by Brytten E. Steed, USDA Forest Service, R1 Forest Health Protection.

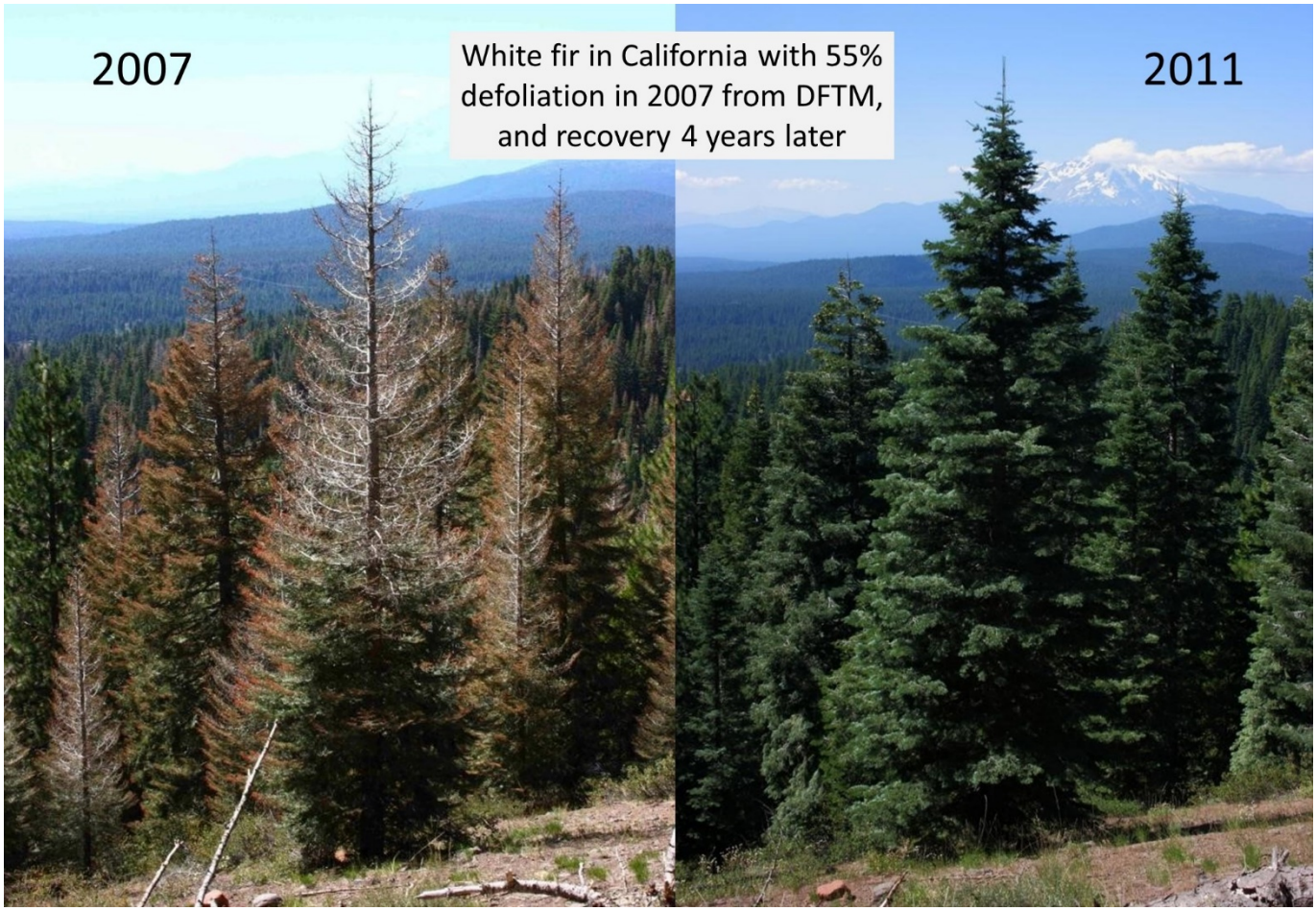
Adult WSBW moths also look different from DFTM adults in color, shape, and size.

PHOTO TITLE: Western spruce budworm adult moths

Photo by Brytten E. Steed, USDA Forest Service, R1 Forest Health Protection.

For more information see the fact sheet on Western spruce budworm from Natural Resources Canada.

TAB 3: DAMAGE EFFECTS



TAB 3 PHOTOGRAPH is of white fir in California during defoliation event and after
Photos by Don Owens, CALFIRE (retired)

Defoliation Effects

Defoliation levels vary significantly across the landscape, with heavy defoliation occurring in hotspots up to several hundred acres in size. These hotspots typically occur on ridges, upper slopes, east and southeast aspects, and poorer sites. Resulting damage includes growth loss, top kill, and tree mortality. Outbreaks are generally cyclic with a 7-10 year return interval.

DFTM outbreaks can completely defoliate host trees in 1-4 years due to their ability to eat old as well as new needles. Although growth loss can be significant, surviving trees often fully recover, and defoliation levels must be high to result in tree mortality. Even where heavy defoliation does not result in direct mortality, trees may experience suppressed growth for up to 4 years after an outbreak, often followed by increased tree growth and recruitment with recovery.

PHOTO TITLE: Defoliation of Douglas-fir on ridge-top near Missoula, MT as seen from the air

Photo by Scott Sontag, USDA Forest Service, R1 Forest Health Protection

Mortality is most likely when defoliation occurs in conjunction with poor site conditions, drought, or subsequent bark beetle attack on weakened trees. Older (>50 years old), multi-storied, dense stands dominated by Douglas-fir or other host tree species are at highest risk. A study in California found that the percent of the crown that has been completely consumed by DFTM had to reach 90% or greater for trees to die; few trees with less than 50% defoliation died from DFTM alone (e.g. photos at right show recovery of white fir after 55% crown loss from DFTM defoliation). However, trees with 60-90% defoliation appear more vulnerable to mortality from bark beetle attack (Douglas-fir beetle, Douglas-fir pole beetle, other secondary bark beetles and wood borers).

Additional information on hazard rating stands for susceptibility to Douglas-fir beetle can be found here.

Do not assume your defoliated tree is dead just yet!

Wait until spring bud break to determine if your tree is producing new needles. Only when you do not see new foliage should you begin to assume your tree (or top of tree) is dead.

PHOTO TITLE: Douglas-fir tree with 30% canopy defoliation by DFTM in 2007

Photo by Don Owens, CALFIRE (retired)

PHOTO TITLE: Same Douglas-fir tree four years after 30% canopy defoliation by DFTM (2011)

Photo by Don Owens, CALFIRE (retired)

PHOTO TITLE: White fir tree in California with 60% canopy defoliation

Photo by Don Owens, CALFIRE [retired]

PHOTO TITLE: Same white fir tree in California four years after 60% canopy defoliation (2011). Top kill and branch mortality have resulted but tree is still alive and recovering.

Photo by Don Owens, CALFIRE [retired]

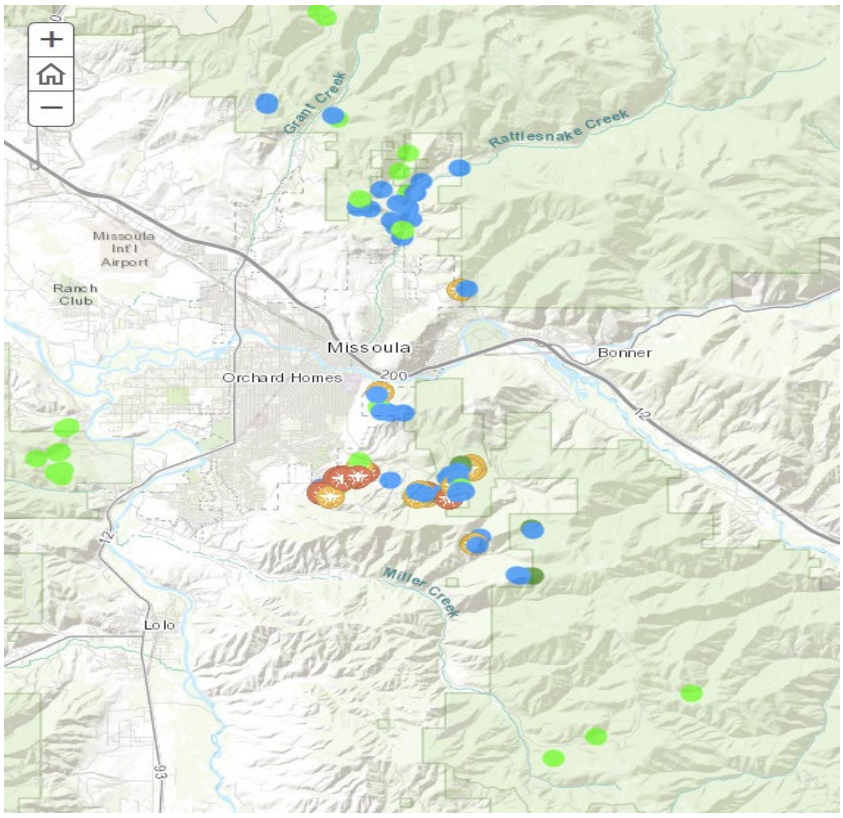
Feeding by the first three larval instars accounts for about 10% of the trees defoliation; the last instar accounts for more than 60% of the defoliation. Thus, any direct population control should be done before larvae hit this final larval stage.

Outbreaks collapse naturally due primarily to a nuclear polyhedrosis virus (NPV), parasites and predators, and starvation (see TAB 6).

For more info see Management Guide for Douglas-fir Tussock Moth from the Northern and Intermountain Regions.

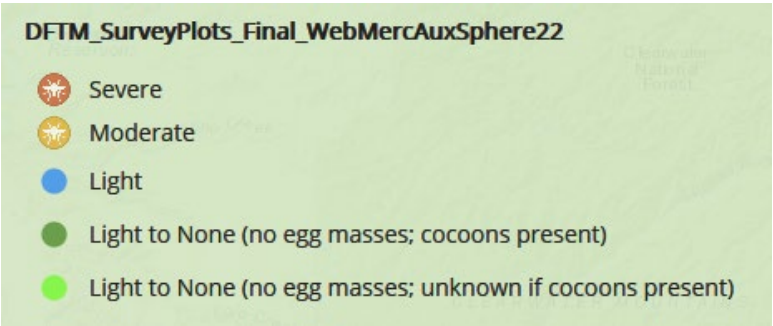
TAB 4: GROUND SURVEYS – 2019

Survey Results



TAB 4 INTERACTIVE MAP is shown in this screen capture indicating locations of 2019 ground surveys. The data that appears for each point are provided in Appendix A

LEGEND TITLE: Symbols on the map at right indicate the severity of suspected 2020 defoliation based on the average number of egg masses found per tree.



DFTM has been detected previously in limited numbers around Missoula although most defoliation in the area has been attributed to WSBW; 2019 marks the first year in over 50 where large patches of defoliation were attributed to DFTM. Defoliation from DFTM was particularly notable in the Miller Creek and Big Flat areas although caterpillars were found in areas with less dramatic defoliation.

To determine DFTM presence and activity levels, ground surveys were conducted by USDA Forest Service, Forest Health Protection (FHP) personnel in and around the Missoula area. Survey crews randomly chose locations in Douglas-fir-dominated stands inside and outside of heavily defoliated areas. Recreation areas were of particular interest to managers and the public so surveys were concentrated at Pattee Canyon, Rattlesnake, Blue Mountain, and other trail-heads.

PHOTO TITLE: A heavily defoliated Douglas-fir with many cocoons and egg masses found at a ground survey plot near Missoula.

Photo by Jacob S. Chadwell, USDA Forest Service, R1 Forest Health Protection.

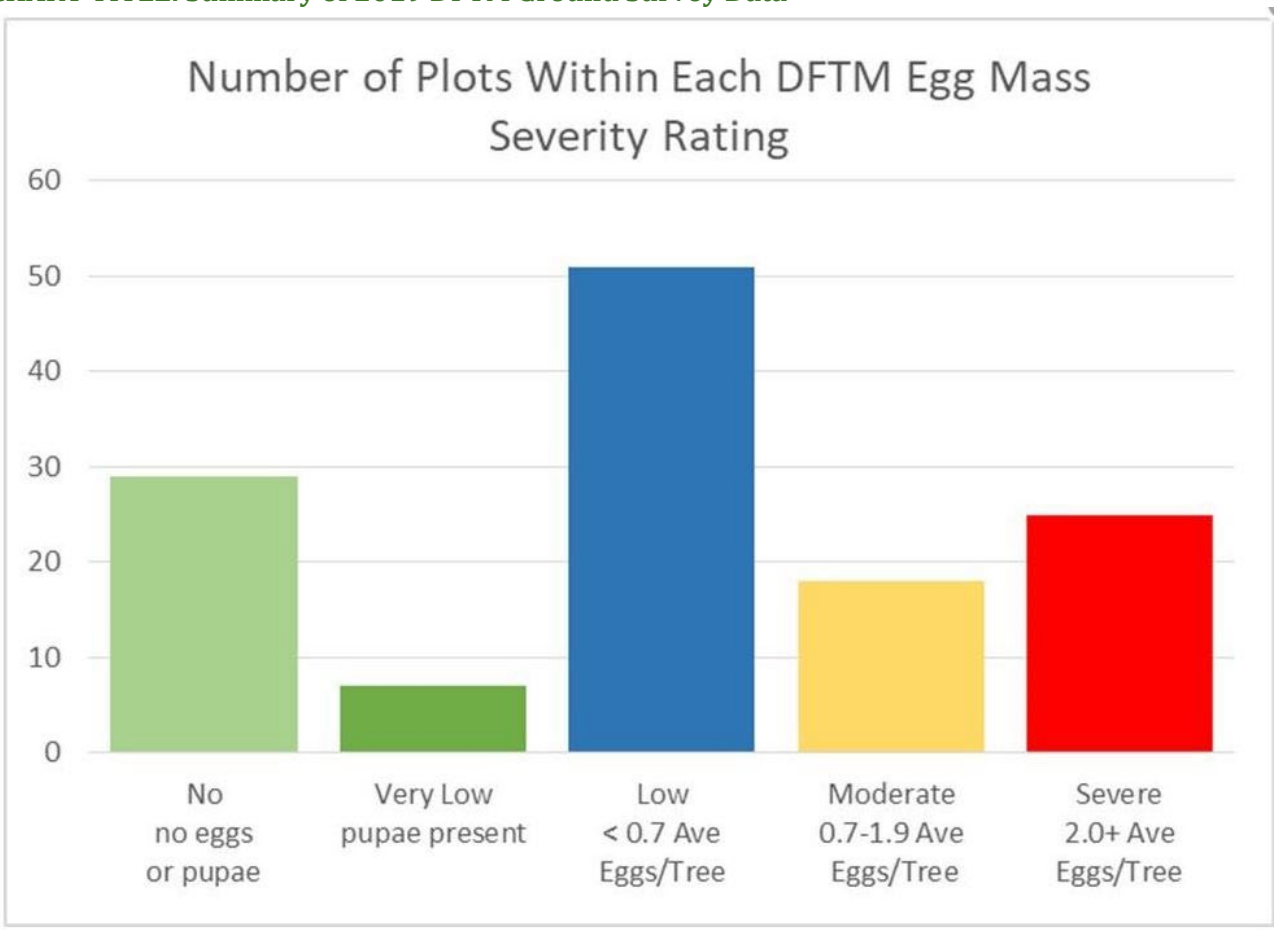
At each location 20 host trees (mostly Douglas-fir) were examined. On each tree the egg masses were counted on three randomly chosen branches. Additional information was noted including the health of the egg masses, presence of cocoons if egg masses weren't present, tree species, and presence of WSBW defoliation.

For a similar protocol description see Shepherd and others (1985):

Shepherd, R. F.; Otvos, I. S.; Chorney, R. J. 1985. Sequential sampling for Douglas-fir tussock moth egg masses in British Columbia. Joint Rep. 15. Canadian Forest Service, Pacific Forest Research Centre. 7 p.

RESULTS Of GROUND SURVEYS are shown in the map to the right. The likelihood of increased defoliation in 2020 is indicated by the average number of egg masses per tree. Some locations are in their second or third years of the outbreak cycle and are likely see population crash next year due to nuclear polyhedral virus (NPV) and other natural enemies. Some locations are in their first year of outbreak cycle and defoliation is likely to continue into 2020/2021. When transparent pupae are found in a location, it can indicate the end of the outbreak there (see TAB 6).

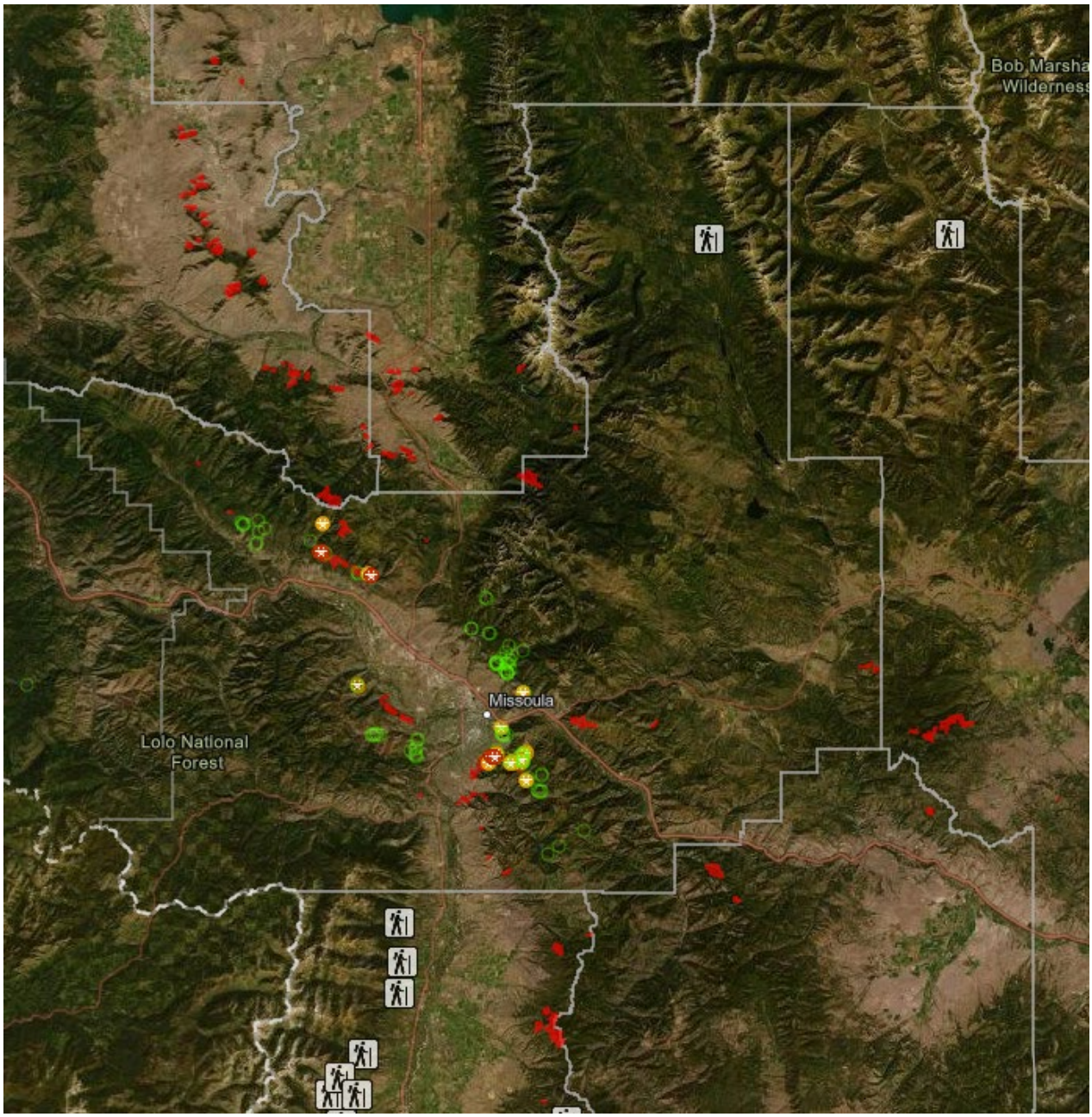
CHART TITLE: Summary of 2019 DFTM Ground Survey Data



The cause for the DFTM population increases and their appearance in atypical areas is unknown although dense stands of Douglas-fir, a loss or change in controlling agents, or weather may play a roll.

TAB 5: CURRENT AND FUTURE DFTM ACTIVITY

Aerial and Ground Survey



TAB 5 INTERACTIVE MAP is shown in this screen capture where both aerial detection survey and ground survey location and severity are displayed.

DFTM females are flightless, and wind-dispersing larvae rarely travel more than 550 feet (500 meters) and do not produce new outbreak areas. Thus, outbreaks must build from successful local populations.

Ground surveys provide some indication of future activity (points). In addition, **aerial survey** conducted by USDA Forest Service Forest Health Protection provides information on 2019 activity (red polygons). **SEE MAP LEGEND BELOW**

LEGEND TITLE: Symbols on the map at right (above) indicate the severity of suspected 2020 defoliation based on the average number of egg masses found per tree. Additional red polygons show where aerial detection survey detected DFTM activity. Trailheads and the County boundaries are also noted.

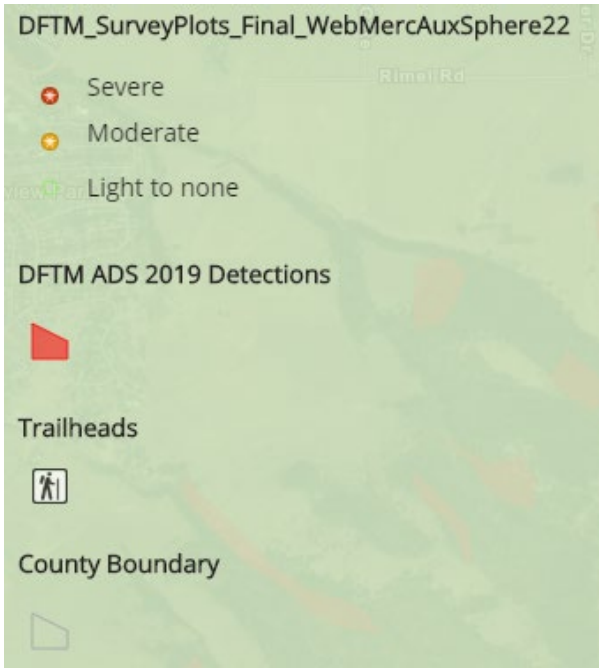
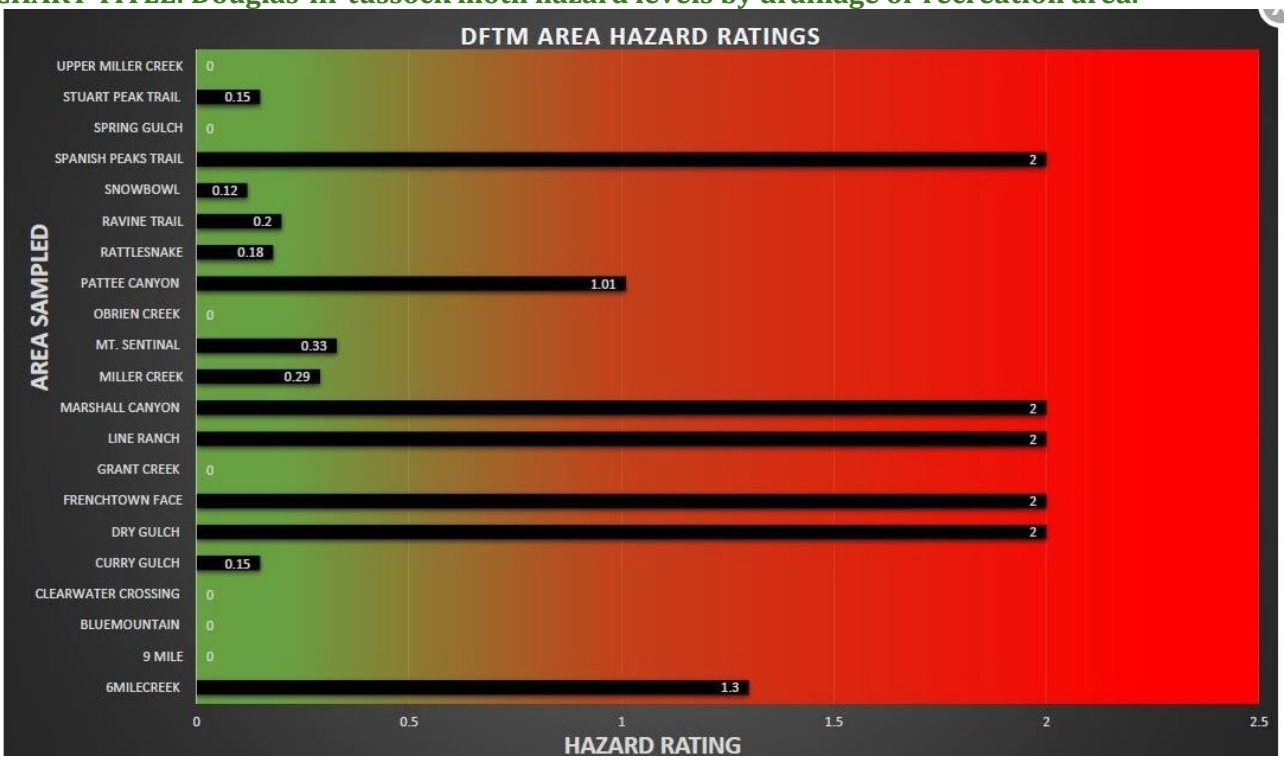


PHOTO TITLE: Hot spots of DFTM-caused defoliation near Missoula as seen during aerial detection surveys conducted summer 2019 by USDA Forest Service, Forest Health Protection.

Photo by Scott Sontag, USDA Forest Service, R1 Forest Health Protection.

Areas of high defoliation in 2019 (aerial survey) may not be hot spots in 2020 although they may look unhealthy until crowns have recovered. Populations may also increase around polygon edges if host and site conditions are conducive to survival. The best indication of future defoliation are ground surveys (points) which assess egg masses that will hatch spring 2020. Based on egg mass surveys, some areas listed below are expected to see increased or continued activity, at least in pockets.

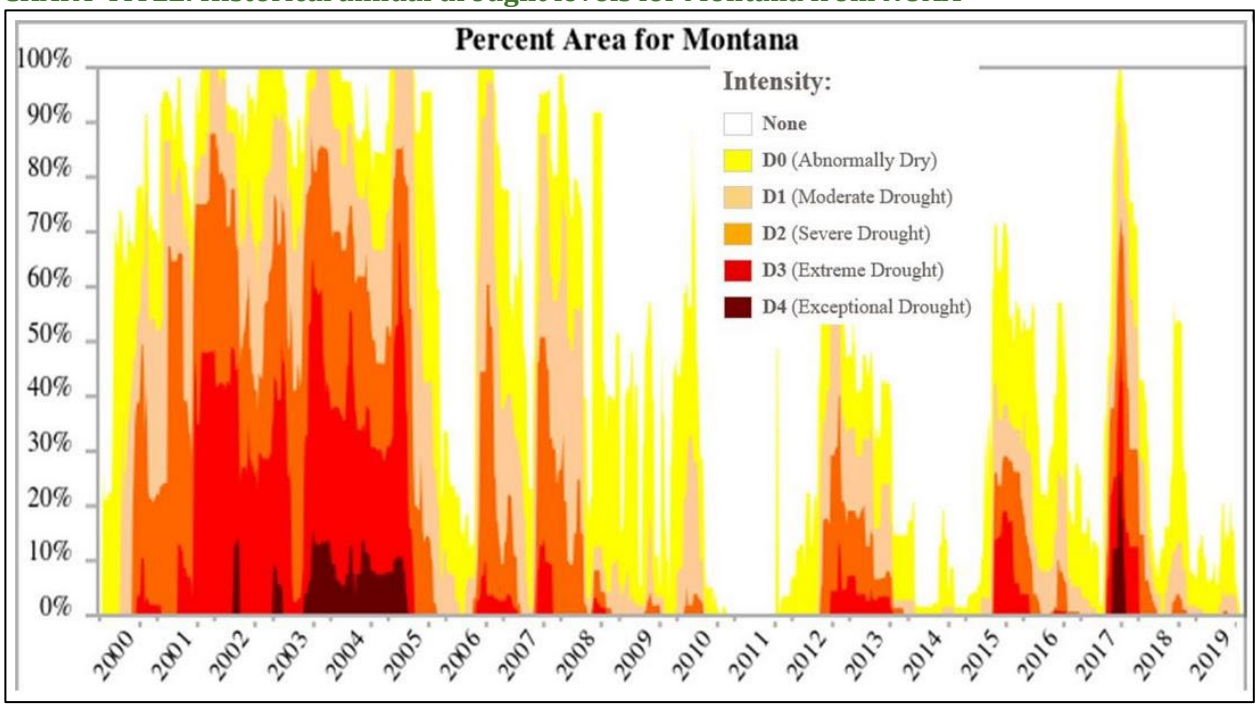
CHART TITLE: Douglas-fir tussock moth hazard levels by drainage or recreation area.



The maximum hazard rating provided is 2 although some areas had more egg masses than others in this severe level.

Mortality of defoliated trees is known to be affected by other stressors, particularly drought and site conditions that create drought-like stresses. Recent weather is indicative of climatic trends to hotter and drier summers which may result in significant mortality of trees when defoliation events occur.

CHART TITLE: Historical annual drought levels for Montana from NOAA



Graphic from ***NOAA website***

Aerial Survey Disclaimer: Forest Health Protection (FHP) and its partners strive to maintain an accurate Aerial Detection Survey (ADS) Dataset, but due to the conditions under which the data are collected, FHP and its partners shall not be held responsible for missing or inaccurate data. ADS are not intended to replace more specific information. An accuracy assessment has not been done for this dataset; however, ground checks are completed in accordance with local and national guidelines. Visit *here* for more information.

TAB 6: NATURAL CONTROLS (AND MONITORING)

TAB 6 PHOTOGRAPH shows a fly and beetle predator killing a Douglas-fir tussock moth.
Photo by Jessica L. Jenne, USDA Forest Service, Forest Health Protection, Missoula Field Office

Predators, Parasites, and Diseases

Outbreaks collapse naturally due primarily to a nuclear polyhedrosis virus (NPV), parasites and predators, and starvation.

Predation by a beetle (*Temnochila* sp.) and possible parasitism from a fly were photographed attacking DFTM larvae in the Missoula area (photo above)

NPV is the most important agent in the collapse of DFTM outbreaks. The virus is always present in the soil but takes time to build up in larvae to affect control. When infected larvae die they cling to the tree while their exoskeleton ruptures, showering more virus onto foliage below, infecting more larvae.

PHOTO TITLE: DFTM larvae infected and killed by nuclear polyhedrosis virus (NPV)

Photo by Tom Eckberg, ID Dept. of Lands

Compare old or unhealthy egg mass with the example on TAB 1.

Egg masses from the previous year will look tattered with hatched eggs sometimes visible.

PHOTO TITLE: Old DFTM egg mass from previous year

Photo by Jacob S. Chadwell, USDA Forest Service, R1 Forest Health Protection

Eggs and pupae that are parasitized can look off color or deformed, or have other insects present. Most of the parasitoids are small wasps (Braconids, *Trichogramma* spp., *Telenomus californicus*, etc.) or flies.

PHOTO TITLE: DFTM pupae parasitized by fly larvae

Photo by Tom Eckberg, Idaho Department of Lands

When larvae become sick with NPV they are unable to construct complete cocoons. These incomplete cocoons from sick larvae appear transparent. Larvae usually die. Predators may quickly consume the larvae making it most likely you'll observe nothing but an empty cocoon.

PHOTO TITLE: DFTM "transparent" cocoons created by sick larvae

Photo by Tom Eckberg, Idaho Department of Lands

Photo by Tom Eckberg, Idaho Department of Lands

Cold winters won't kill DFTM eggs, but a late cold front can kill their food supply, affecting early instar survival.

TAB 7: ALLERGIC REACTIONS!

TAB 7 PHOTOGRAPH show the effects of tussockosis, an allergic reaction to the irritating hairs of Douglas-fir tussock moth

Photos by Tom Eckberg, Idaho Department of Lands

It's the irritating hairs!

Tussock moth caterpillars are covered in thousands of tiny urticating hairs. There are also hairs present on the female moth, egg masses and cocoons.

PHOTO TITLE Hairs on the DFTM caterpillars and their cocoons

Photo by Jessica L. Jenne, USDA Forest Service, R1 Forest Health Protection

These hairs may cause an allergic reaction called **tussockosis**. Itching is the most common complaint, but other symptoms include rashes (with welts or blisters), watery eyes, runny nose, cough and, less commonly, shortness of breath, wheezing, and chest tightness. People with a general history of allergies may be more susceptible to tussockosis. The degree of irritation depends on the severity of the outbreak, amount of contact with caterpillars and the sensitivity of the individual. If a person is very sensitive, these reactions may be cumulative, increasing in severity with repeated exposure.

IF YOU ARE SENSITIVE, MINIMIZE YOUR EXPOSURE TO AREAS OF HIGH TUSSOCK MOTH ACTIVITY!

Nearly one in five people display symptoms of tussockosis, with four in five reported in some areas! Here are a few precautions to minimize these effects. People allergic to other things can be more sensitive.

Avoid infested areas

Avoid handling the caterpillars or any other life stage. Wear gloves if necessary.

Wash hands and any exposed skin frequently with soap and water.

Change clothing and take a cool shower in areas of heavy infestation.

Do not shake clothing prior to laundering.

Wash outdoor furniture and equipment before use.

Use an over the counter remedy for minor itching if symptoms persist.

If you are experience severe symptoms seek medical attention immediately.

TAB 8: FOR MORE INFORMATION…

TAB 8 PHOTOGRAPH is of the underside of a Douglas-fir tussock moth
(photo by J. Jenne, US Forest Service, Forest Health Protection, Missoula Field Office)

More information…

A significant amount of published literature on DFTM is available through the internet and through the Northern Region, USDA Forest Service, Forest Health Protection office.

PICTURE TITLE: Forest Health Protection logo

Visit the Northern Region FHP website!

USDA Forest Service, Forest Health Protection has numerous publications related to identification and to management. Forest Insect and Disease Leaflets are also available here.

Private land owners and state or city land managers should contact MT Department of Natural Resources (DNRC) for questions related to their lands.

APPENDIX A: DATA FOR ALL 2019 GROUND SURVEY POINTS (GPS LOCATIONS DELETED)

Sampling protocol loosely followed that described in Shepherd and others (1985). Principle deviations include 1) choice of survey "center" was made randomly in areas dominated by Douglas-fir versus searching for areas with highest egg-mass density to initiate sampling, 2) egg mass viability may be somewhat overestimated when masses were not not clearly in poor condition, and 3) the three branches chosen for survey were in lower canopy but might not have been the three lowest.

AREA NAME[1]	OWNER[2]	ELEV-FT	#TREES[3]	EGGS-TOTAL[4]	EGGS-AVE[5]	HAZ RATE[6]	EGGS-MIN	EGGS-MAX	PUPAL[7]	WSBW[8]	%DF[9]	DATE	VIABILITY[10]
6MILECREEK	FED	5141	20	26	1.3	M	0	4			100	9.18.19	
6MILECREEK	FED	4303	20	0	0	No	0	0			100	10.16.19	
9 MILE/GRAND MENARD	FED	3519	20	0	0	No	0	0			100	9.18.19	
9 MILE/GRAND MENARD	FED	3433	20	0	0	No	0	0			100	9.18.19	
9 MILE/KRIES POND	FED	3707	20	0	0	VL (P)	0	0	Y	Y	100	9.18.19	
9 MILE/KRIES POND	FED	3753	20	0	0	VL (P)	0	0	Y	Y	100	9.18.19	
9 MILE/KRIES POND	FED	3638	20	0	0	No	0	0			100	9.18.19	
9MILE	FED	3996	20	0	0	No	0	0			100	9.18.19	
9MILE	FED	3760	20	0	0	No	0	0			100	9.18.19	
9MILE	FED	3959	20	0	0	No	0	0			100	9.18.19	
9MILE	FED	3714	20	0	0	No	0	0			100	9.18.19	
BLUEMOUNTAIN	FED	4094	20	0	0	No	0	0			100	9.30.19	
BLUEMOUNTAIN	FED	3967	20	0	0	No	0	0			100	9.30.19	
BLUEMOUNTAIN	FED	4026	20	0	0	No	0	0			100	9.30.19	
BLUEMOUNTAIN	FED	4062	20	0	0	No	0	0			100	9.30.19	
BLUEMOUNTAIN	FED	3668	20	0	0	No	0	0			100	10.01.19	
BLUEMOUNTAIN	FED	3635	20	0	0	No	0	0			100	10.01.19	
BLUEMOUNTAIN	FED	3570	20	0	0	No	0	0			100	10.01.19	
BLUEMOUNTAIN	FED	3484	20	0	0	No	0	0			100	10.01.19	
CLEARWATER CROSSING	STATE	3497	20	0	0	No	0	0			100	9.19.19	
CURRY GULCH	FED	3875	20	3	0.15	L	0	2	Y	Y	100	10.11.19	
CYR BRIDGE	PVT	2955	20	0	0	No	0	0			100	9.18.19	
DRY GULCH	PVT	4160	5	40	8	S	5	8	Y	Y	100	9.30.19	
DRY GULCH	PVT	4104	4	40	10	S	7	13	Y	Y	100	9.11.19	
DRY GULCH	PVT	4232	3	40	13.3	S	10	26	Y	Y	100	9.11.19	
DRY GULCH	PVT	4045	3	40	13.3	S	12	17	Y	Y	100	9.11.19	
DRY GULCH	PVT	4108	20	0	0	VL (P)	0	0	y	y	100	9.11.19	
DRY GULCH	PVT	3031	20	8	0.4	L	0	3	Y	Y	100	9.11.19	
DRY GULCH	PVT	4061	20	0	0	NO	0	0			100	10.1.19	
DRY GULCH	PVT	3951	20	0	0	NO	0	0		Y	100	10.1.19	
FRENCHTWN FACE	FED	4094	3	40	13.3	S	8	24	Y	Y	100	9.19.19	

AREA NAME[1]	OWNER[2]	ELEV-FT	#TREES[3]	EGGS-TOTAL[4]	EGGS-AVE[5]	HAZ RATE[6]	EGGS-MIN	EGGS-MAX	PUPAL[7]	WSBW[8]	%DF[9]	DATE	VIABILITY[10]
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FRENCHTWN FACE	FED	4029	20	40	2	S	0	6	Y	Y	100	9.19.19	
FRENCHTWN FACE	FED	4009	9	40	4.4	S	2	7	Y		100	9.19.19	
FRENCHTWN FACE	FED	3947	13	40	3	S	0	6	Y		100	9.19.19	
FRENCHTWN FACE	FED	3911	7	40	5.7	S	1	10	Y		100	9.19.19	
FRENCHTWN FACE	FED	3776	20	3	0.15	L	0	2	Y		100	9.23.19	
FRENCHTWN FACE	FED	3999	20	15	0.75	M	0	3	Y		100	9.23.19	
FRENCHTWN FACE	FED	4170	20	40	2	S	0	7	Y		100	9.23.19	
FRENCHTWN FACE	FED	3696	20	1	0.05	L	0	1	Y	Y	100	9.23.19	
FRENCHTWN FACE	FED	4139	20	0	0	No	0	0			100	9.19.19	
FRENCHTWN FACE	FED	3988	20	40	2	S	0	3			100	9.19.19	
GRANT CREEK	FED	4337	20	0	0	No	0	0		Y	100	9.25.19	
LINE RANCH	PVT	5098	20	0	0	No	0	0		Y	100	10.03.19	
LINE RANCH	PVT	4170	20	4	0.2	L	0	3	Y	Y	100	10.3.19	Many unviable
LINE RANCH	PVT	4288	20	11	0.5	L	0	4	Y	Y	100	10.3.19	Many unviable
LINE RANCH	PVT	4373	20	21	1.05	M	0	6	Y	Y	100	10.2.19	
LINE RANCH	PVT	3876	6	40	6.6	S	3	10	Y	Y	100	10.2.19	
LINE RANCH	PVT	3829	20	20	1	M	0	4	Y	Y	100	10.2.19	
LINE RANCH	PVT	4310	20	40	2	S	12	19	Y	Y	100	10.2.19	
LINE RANCH	PVT	4100	5	40	8	S	0	15	Y	Y	100	10.2.19	
LINE RANCH	PVT	4206	5	40	8	S	6	20	Y	Y	100	10.2.19	
LINE RANCH	PVT	4355	4	40	10	S	5	17	Y	Y	100	10.2.19	
LINE RANCH	PVT	4496	2	40	20	S	17	23	Y	Y	100	10.3.19	
LINE RANCH	PVT	4633	5	40	8	S	4	12	Y	Y	100	10.3.19	
LINE RANCH	PVT	5000	20	23	1.15	M	0	6	Y	Y	100	10.3.19	
SPANISH PEAKS TRAIL	PVT	4189.633	20	0	0	NO	0	0			100	10.2.19	
SPANISH PEAKS TRAIL	PVT	3612.861	20	0	0	No	0	0			100	10.2.19	
MARSHALL CANYON	STATE	4009	20	27	1.35	M	0	9	Y	Y	100	9.11.19	
MARSHALL CANYON	STATE	3238	20	13	0.65	L	0	7			100	9.11.9	Some unviable
MILLER CREEK	FED	5810	20	4	0.2	L	0	2	Y	Y	100	9.12.19	Some unviable
MILLER CREEK	FED	5843	20	0	0	VL (P)	0	0	Y	Y	100	9.12.19	
MILLER CREEK	FED	5873	20	1	0.05	L	0	1	Y	Y	45	9.12.19	
MILLER CREEK	FED	5853	20	10	0.5	L	0	3	Y	Y	100	9.12.19	

AREA NAME[1]	OWNER[2]	ELEV-FT	#TREES[3]	EGGS-TOTAL[4]	EGGS-AVE[5]	HAZ RATE[6]	EGGS-MIN	EGGS-MAX	PUPAL[7]	WSBW[8]	%DF[9]	DATE	VIABILITY[10]
MILLER CREEK	FED	3258	20	24	1.2	M	0	5	Y	Y	100	9.12.9	
MILLER CREEK	FED	5177	20	9	0.45	L	0	2	Y	Y	100	9.12.19	
MILLER CREEK	FED	5335	20	0	0	VL (P)	0	0	Y	Y	65	9.12.19	
MILLER CREEK	FED	5217	20	4	0.2	L	0	1	Y	Y	100	9.12.19	
MILLER CREEK	FED	5364	20	5	0.25	L	0	2	Y	Y	100	9.12.19	
MT. SENTINAL	UOFM	4413	20	37	1.85	M	0	9	Y	Y	100	9.24.19	
MT. SENTINAL	UOFM	5033	20	1	0.05	L	0	1	Y	Y	100	9.24.19	
MT. SENTINAL	UOFM	4528	20	1	0.05	L	0	1	Y	Y	100	9.24.19	
MT. SENTINAL	UOFM	4364	20	0	0	No	0	0		Y	100	9.24.19	
MT. SENTINAL	PVT	4264	20	1	0.05	L	0	1	Y		100	9.24.19	
MT. SENTINAL	PVT	4796	20	2	0.1	L	0	1	Y	Y	100	9.25.19	
MT. SENTINAL	PVT	4626	20	5	0.25	L	0	3	Y	Y	100	9.25.19	
OBRIEN CREEK	FED	3766	20	0	0	No	0	0			100	9.16.19	
OBRIEN CREEK	FED	3600	20	0	0	No	0	0			100	9.16.19	
OBRIEN CREEK	FED	3735	20	0	0	No	0	0			100	9.16.19	
OBRIEN CREEK	FED	3717	20	0	0	No	0	0			100	9.16.19	
OBRIEN CREEK	FED	3780	20	0	0	VL (P)	0	0	Y		100	9.16.19	
OBRIEN CREEK	FED	3753	20	0	0	No	0	0			100	9.16.19	
PATTEE CANYON	FED	4285	20	38	1.9	M	0	8	Y		100	9.10.19	
PATTEE CANYON	FED	4180	20	40	2	S	0	8	Y		100	9.10.19	
PATTEE CANYON	FED	4249	20	3	0.15	L	0	2	Y		100	9.10.19	
PATTEE CANYON	PVT	4370	19	40	2.1	S	0	8	Y	Y	100	9.12.19	
PATTEE CANYON	FED	4062	20	13	0.65	L	0	2	Y	Y	100	9.10.19	
PATTEE CANYON	FED	4058	20	13	0.65	L	0	2	Y	Y	100	9.10.19	
PATTEE CANYON	FED	4022	20	6	0.3	L	0	2	Y	Y	100	9.10.19	
PATTEE CANYON	FED	4052	20	4	0.2	L	0	1	Y	Y	100	9.10.19	
PATTEE CANYON	FED	4285	20	30	1.5	M	0	4	Y	Y	100	9.10.19	
PATTEE CANYON	FED	4275	20	38	1.9	M	0	4	Y	Y	100	9.10.19	
PATTEE CANYON	FED	4239	20	26	1.3	M	0	3	Y	Y	100	9.10.19	
PATTEE CANYON	FED	4124	20	17	0.85	M	0	4	Y	Y	100	10.4.19	
PATTEE CANYON	FED	4134	20	28	1.4	M	0	5	Y	Y	100	10.4.19	
PATTEE CANYON	FED	4108	20	16	0.8	M	0	2	Y	Y	100	10.4.19	
PATTEE CANYON	FED	4094	20	26	1.3	M	0	6	Y	Y	100	10.3.19	
PATTEECANYON	FED	4039	20	6	0.3	L	0	3	Y	Y	100	10.3.19	
PATTEECANYON	FED	4091	20	0	0	VL (P)	0	0	Y	Y	100	10.3.19	
RATTLESNAKE	FED	3688	20	3	0.15	L	0	3	Y		100	9.11.19	
RATTLESNAKE	FED	3720	20	1	0.05	L	0	1	Y		100	9.11.19	
RATTLESNAKE	FED	3891	20	2	0.1	L	0	2	Y		100	9.11.19	
RATTLESNAKE	FED	3937	20	1	0.05	L	0	1	Y		100	9.11.19	
RATTLESNAKE	FED	3688	20	1	0.05	L	0	1	Y		100	9.11.19	

AREA NAME[1]	OWNER[2]	ELEV-FT	#TREES[3]	EGGS-TOTAL[4]	EGGS-AVE[5]	HAZ RATE[6]	EGGS-MIN	EGGS-MAX	PUPAL[7]	WSBW[8]	%DF[9]	DATE	VIABILITY[10]
RATTLESNAKE	FED	3776	20	0	0	No	0	0			100	9.11.19	
RATTLESNAKE	FED	3720	20	1	0.05	L	0	1	Y		100	9.11.19	
RATTLESNAKE	FED	3625	20	1	0.05	L	0	1	Y		100	9.11.19	
RATTLESNAKE	FED	4094	20	5	0.25	L	0	3	Y		100	9.10.19	
RATTLESNAKE	FED	4088	20	1	0.05	L	0	1	Y	Y	100	9.10.19	
RATTLESNAKE	FED	4114	20	34	1.7	M	0	7	Y	Y	100	9.10.19	
RATTLESNAKE	FED	4357	20	15	0.75	M	0	6	Y	Y	100	9.10.19	Some unviable
RATTLESNAKE	FED	3940	20	0	0	No	0	0			100	9.11.19	
RATTLESNAKE	FED	4026	20	6	0.3	L	0	1	Y		100	9.11.19	
RATTLESNAKE	FED	4081	20	6	0.3	L	0	4	Y		100	9.11.19	
RATTLESNAKE	FED	3599	20	0	0	No	0	0			100	9.11.19	
RATTLESNAKE	FED	3599	20	0	0	No	0	0			100	9.11.19	
RATTLESNAKE	FED	3586	20	1	0.05	L	0	1	Y		100	9.11.19	
RATTLESNAKE	FED	3632	20	0	0	No	0	0			100	9.11.19	
RATTLESNAKE	FED	4127	20	4	0.2	L	0	2	Y	Y	100	9.10.19	
RATTLESNAKE	FED	4236	20	0	0	No	0	0		Y	100	9.10.19	
RATTLESNAKE	FED	4295	20	5	0.25	L	0	2	Y	Y	100	9.10.19	
RATTLESNAKE	FED	4409	20	5	0.25	L	0	2	Y		100	9.10.19	
RATTLESNAKE	FED	4268	20	4	0.2	L	0	1	Y	Y	100	9.10.19	
RATTLESNAKE	FED	4199	20	7	0.35	L	0	2	Y	Y	100	9.10.19	
RATTLESNAKE	FED	4242	20	4	0.2	L	0	2	Y	Y	100	9.10.19	
RATTLESNAKE	FED	4236	20	1	0.05	L	0	1	Y	Y	100	9.10.19	
RATTLESNAKE	FED	3642	20	1	0.05	L	0	1	Y		100	10.7.19	
RATTLESNAKE	FED	3770	20	2	0.1	L	0	1	Y	Y	100	10.7.19	
RATTLESNAKE	FED	3900	20	1	0.05	L	0	1	Y		100	10.7.19	
RATTLESNAKE	FED	3965	20	3	0.15	L	0	1	Y		100	10.7.19	
RAVINE TRAIL	FED	4183	20	4	0.2	L	0	1	Y		100	9.25.19	
SNOWBOWL	PVT	4967	20	0	0	No	0	0		Y	100	9.25.19	
SNOWBOWL	PVT	4327	20	2	0.1	L	0	2	Y	Y	100	9.25.19	
SNOWBOWL	PVT	4882	20	0	0	No	0	0			100	9.25.19	
SNOWBOWL	PVT	4275	20	8	0.4	L	0	2	Y	Y	100	9.25.19	
SPANISH PEAKS TRAIL	PVT	4291	1	40	40	S	40	40	Y		100	10.2.19	
SPANISH PEAKS TRAIL	STATE	4199	11	40	3.6	S	0	10	y	y	100	10.2.19	
SPANISH PEAKS TRAIL	STATE	4193	7	40	5.7	S	1	12	Y	Y	100	10.2.19	
SPANISH PEAKS TRAIL	STATE	4357	8	40	5	S	1	9	Y	Y	100	10.2.19	

AREA NAME[1]	OWNER[2]	ELEV-FT	#TREES[3]	EGGS-TOTAL[4]	EGGS-AVE[5]	HAZ RATE[6]	EGGS-MIN	EGGS-MAX	PUPAL[7]	WSBW[8]	%DF[9]	DATE	VIABILITY[10]
SPANISH PEAKS TRAIL	PVT	4226	1	40	40	S	40	40			100	10.2.19	
SPRING GULCH	FED	4050	20	0	0	No	0	0			100	10.11.19	
SPRING GULCH	FED	4173	20	0	0	No	0	0			100	10.11.19	
SPRINGGULCH	FED	4009	20	0	0	No	0	0			100	9.11.19	
STUART PEAK TRAIL	FED	3780	20	1	0.15	L	0	1	Y		100	10.11.19	
UPPER MILLER CRK	FED	4875	20	0	0	No	0	0		Y	100	10.2.19	
UPPER MILLER CRK	FED	5098	20	0	0	No	0	0		Y	80	10.2.19	
UPPER MILLER CRK	FED	5410	20	20	0	No	0	0		Y	55	10.2.19	

[1]Name of the general area sampled given as the recreation area name, trail name, drainage, or ownership area.

[2]Ownership as federal (FED), state (STATE), or private (PVT)

[3]Number of trees sampled. Up to 20 trees were sampled at random in the immediate area, or as many trees as it took to reach 40 total egg masses.

[4]Total number of egg masses counted over all trees in the sample. Viability was not considered except when clearly unviable.

[5]Average number of egg masses at the given location as calculated by "eggs-total" divided by "#trees

[6]Hazard Rating based on the average number of egg masses as described in Shepherd and others (1985):

- Less than 0.7, then you can expect light defoliation (L) or no defoliation at all in that stand the following year.
- Between 0.7 and 1.9, then you can expect moderate defoliation (M). The defoliation will be highly variable in intensity between trees. Some growth loss is likely to occur.
- More than 2.0, then you can expect severe defoliation (S) and significant growth loss. Some top kill and tree mortality may also be expected.

[7]Presence of DFTM pupal cases indicated DFTM activity even where egg masses may not have been observed.

[8]Western spruce budworm (WSBW) was also common in stands defoliated by DFTM. A "Y" indicates WSBW pupal cases were found in the trees surveyed. Thus, defoliation at this site is likely a combination of both defoliating insects. Note that a blank does not mean WSBW was not present; early surveys or some survey groups did not collect this data.

[9]Percent of trees surveyed that were Douglas-fir. Other tree species include Engelmann spruce and subalpine fir.

[10]Viability of egg masses was not as closely observed early in our survey but we later learned to better discern this. Any notes on viability were noted here.

Literature Cited for Appendix A

Shepherd, R. F.; Otvos, I. S.; Chorney, R. J. 1985. Sequential sampling for Douglas-fir tussock moth egg masses in British Columbia. Joint Rep. 15. Canadian Forest Service, Pacific Forest Research Centre. 7 p.